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ELECTROMECHANICAL DEVICES

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SANDIA DEVICES

Chairman Duimstra began the discussion by commenting about recent work on rolamite electromechanical devices at Sandia. Sandia is working actively on about five different rolamite devices--electromechanical accelerometers, g sensing devices, and things of this nature. "To give you an idea of the versatility of rolamite in sensing inertial fields, I will illustrate two different types of integrating accelerometers that we have been working on. We have worked with three ways to provide damping in an integrating accelerometer. We use a gas to damp the roller cluster and pump air from one chamber to another. We use incompressible fluid such as silicone oil and pump it from one chamber to another. A third way that we've conceived of providing a damping function is to turn rolamite into a mechanical verge escapement."

INTEGRATING ACCELEROMETERS

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VERGE ESCAPEMENT

Figure 1 shows one version of a rolamite verge escapement. In this configuration the verge mass is shown at A. This mass must be free to oscillate about a center at B. One side pin of the verge mass is forced into the "valley" or tooth root of escape wheel C and one side pin is forced up to the "hill" or tooth tip of escape wheel D. Escape wheels C and D are necessarily 1/2 tooth out of phase with one another. As the roller cluster moves left or right the side pins on the verge mass alternately engage the tooth roots and tooth tips on escape wheels C and D and also alternately cam up the tooth surfaces of escape wheels C and D causing the verge mass to oscillate at a rate approximately proportional to the torque applied to escape wheels C and D.

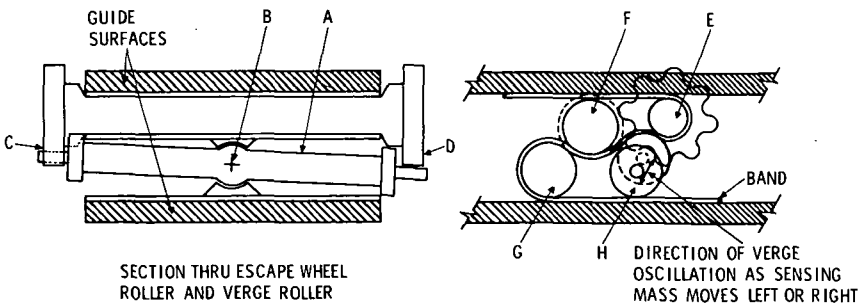

Figure 1. Verge Escapement

The four rollers, E, F, G, and H, verge mass A, and escape wheels C and D--in fact all masses except guide surfaces--perform a sensing mass function. The ratio between the diameter of roller E and escape wheels C and D controls the ratio of the surface velocity of

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escape wheels C and D versus the velocity of the roller cluster. The number of escape wheel teeth passing by the verge mass side pins, the weight of the total sensing mass, and the inertia of the verge mass all are factors determining the damping function the device can perform. Roller F, by the addition of appropriately designed flanges, also serves the useful function of guiding the verge mass to assure that its oscillation is restricted to a curved plane approximately perpendicular to the centers of escape wheels C and D.

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SWITCHING--BAND CONTACT

A workshop question period began with a discussion of electrical contacting via the band. Contacting directly with the bands is a poor idea except with very small currents. Ten amps will probably cause arcing, which may actually take pieces out of the bands and will heat the bands locally around the contact area, causing the mechanical stresses to be extremely strange around the contact area. There are ways of designing contacts in the rolamite for a large number of cycles in contacting, but it probably means introducing some additional contacting members for high current.

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RIVET CONTACTS

For an added contacting member on the band, a precious metal rivet would add some mass. Such members could be allowed to burn away to raise the life expectancy of the contact.

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BAND CURRENT CARRYING CAPACITY

The current carrying capacity of the band must be an important design consideration. If the band is used as a conductive element, its use for one cycle to turn something on and off only once is far different from having the same thing happening repeatedly until the system reaches an equilibrium temperature. Often the band is not a very good current-carrying material; for instance, beryllium copper, the material which should probably be used for this type of system, has about 25 percent of the conductivity of copper. Just about all the good spring materials are 7 percent of copper or lower in conductivity. In the amp range at 110 volts, significant heating occurs, and should be taken into account by redesigning the contacting members. The design should allow for the heat to dissipate. Duimstra pointed out that one of his calculations "showed that a stainless band of the size you might want to use in a small electromechanical device under the conditions described (quite a few amps at 110 volts) could dissipate a few watts, provided the thin band was heat sinked well to the case wall."

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INCREASING CURRENT CARRYING CAPACITY

Conductivity of bands can be increased by plating. However, in electroplating metal on the band in significant thicknesses, the thickness must be such that the stresses in the band and plating are not any greater than that which can be tolerated by the materials involved. A thin gold coating on a beryllium copper band is not going to change the other properties that are necessary for a return spring or the like. As Duimstra defined it, the problem is size-related. "If you're talking about a large rolamite with a heavy band and a lot of width, you can get much more current down the cross section of the band than you could with a small device. As a matter

LIMITATIONS

of fact, we had a problem in current carrying capacity with a device at Sandia. We were planning on laminating a band and putting conductors within two pieces of plastic. The conductors were carried with the rollers so that, at the end of cluster travel, a bare place on the plastic allowed the conductors to contact. But it turned out that, by using this method, we were overheating the plastic and causing delamination and melting of the plastic material because the current was too high. In the devices we're concerned with at Sandia, we're not talking about millions of operating cycles, so our contacting problems are a little bit less severe."

LIMITATIONS--MATERIAL TRANSFER

Another problem that occurred to several people was that of assuring that the arcing (taking place between the roller or band and the stationary contact) could not cause metal splatter where it might interfere with the rolling action.

CONTACT WIPING

Among contacting arrangements which might be used are grooved contact and the band "tab" concept, mentioned in Wilkes' rolamite literature. These concepts cause a controlled amount of rubbing to occur on contacting. This will have a beneficial effect of clearing away contaminants so that low-resistance, metal-to-metal contact can be made. Actually, these rolamite contacting problems are very similar to contacting problems that people had in the past with ordinary relays.

SLIPPAGE

There may be an advantage to having a contact all the way around the roller. If microslip does occur during each cycle, a new contact surface will be presented to be used at each operation. This might make possible a cost savings by making a thinner layer of contact material on the roller, so that a slippage can be turned into an advantage.

SWITCH ACTUATION

Questions on switch actuation with differential tabs from the band and by external forces on the roller were mostly deferred to an afternoon discussion group, Dr. Diller's workshop B-2 on Electrical Switching.

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ROLAMITES USING MAGNETIC EFFECTS

In reply to a question about putting magnetic fields around rolamite clusters, Chairman Duimstra summarized a number of ways in which magnetic circuits can be used in conjunction with rolamite. There are illustrations on how magnetic circuits might be utilized in rolamite geometry in SC-RR-67-657A, D. Wilkes' research report on the rolamite. The rollers themselves can be electromagnets, or one can make the rollers of soft magnetic materials and place electromagnets external to the rollers. There are a large variety of possibilities in utilizing the rolamite suspension in electromagnetic circuits, including some relay models already constructed at Sandia.

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DISPLAY SYSTEMS

One participant was particularly interested in the display devices which showed take-off from a diaphragm or differential. Some of the display devices show linear forms, curves, continuous rotation, multiple needle presentation and the like. Developing the topic, Chairman Duimstra pointed out, "Using the rolamite suspension system for presenting information through a needle-dial system we get

NEEDLE DIAL

some interesting action. By simply attaching a needle to one of the rollers in the rolamite suspension, any point on the needle will circumscribe a trochoidal motion. Over a portion of the trochoidal curve a fairly flat motion results so that in a voltmeter or something of this nature, the center of action would be closer to the point of the needle and you can get your needle to travel a long distance. This would result in a compact meter dial arrangement with good resolution (see Figure 2).

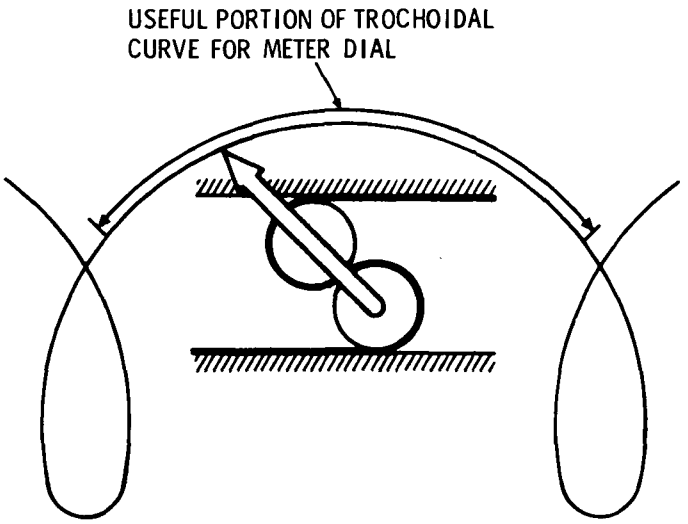

Figure 2. Rolamite Meter Suspension

USING CUTOUTS AND BIAS

"Of course, you must not forget the accessory benefits you could get from rolamite, such as configuring the band to provide spring biasing in a return direction. The spring biasing could be configured to exactly compensate for whatever variances you have in the measuring system; for instance, if you have a DB meter on a log-log scale, you could compensate for the log-log and get it to work on a linear system simply by biasing the return spring in the proper fashion. Another advantage of a rolamite meter suspension system over a conventional needle bearing system would be its reduced susceptibility to shock and vibration."

SUBSTITUTES FOR BAND SUSPENSION

As Ed Ralston (IBM) pointed out, very often one doesn't need the force generation characteristics the band has to offer, but still needs millions and millions of cycles. "Has anybody ever experimented with a series of cables as a suspension system?," he wondered. "Could you get longer fatigue life out of the device in this manner?" The consensus was that it is certainly possible to band a rolamite in this fashion. However, if the cables are single stranded cable, they would have to be of nearly the same thickness as a band because of the fact that the outer fibers would be stressed the same going over the outside curvature of the rollers. Stranded cable may help the situation. However, stranded cable would generate friction within the cable strands as they move along one another.

ELIMINATING BAND

In relation to different methods of suspending rollers, Duimstra mentioned a device which Don Wilkes built not using any band.

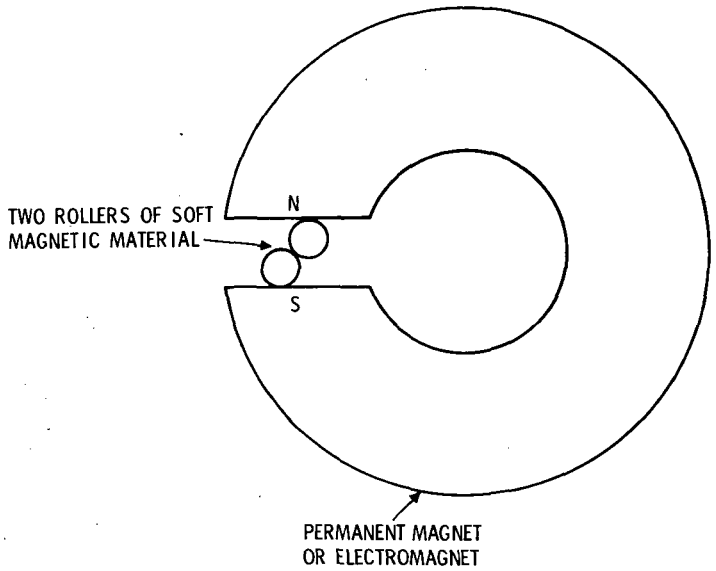

Figure 3. Bandless Rolamite Geometry

If one applies a magnetic field between two guide surfaces and puts two rollers between the surfaces, they automatically assume a rolamite geometry. A fairly linear magnetic field will provide a very friction-free travel of the rolamite cluster without any band at all.